

## Cataract Surgery From The Inside

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Until a few years ago I was a busy cataract surgeon - now I am lying on my back after an injection of I.V sedation with an indelible mark above my left eye. I am looking up at the same operating microscope I spent hours looking down in the past. What follows is a journal account of how I got here, my experience of surgery, and of more interest to me, the experience adapting to monovision 'from the inside.'

I have no history of eye disease, and at age 69 had 6/5 minus in both eyes with a mild hyperopic correction of around + 0.5 spherical equivalent bilaterally, but then things began to change. Over the next 18 months my acuity slowly decreased in low contrast settings. I began to notice difficulty with close work despite upgrading my multifocal spectacles, and decreasing confidence driving on dark country roads at night. Since my retirement home is over an hours drive from Perth, and part of the journey winds along back roads where kangaroos lurk behind trees at dusk, that is a problem. I have normal colour perception, fundi, and macula OCT scans. The right eye was dominant for both far and near with high level stereopsis. Apart from 70 year old lenses in both eyes (LOCS III grading NO3, NC3 with a few spokes and water clefts) the visual axis is clear in both eyes, and when I consulted a former colleague about the change in vision he advised I would benefit from cataract surgery - so here I am.

### Day 0 - Right cataract surgery

The pre-operative dilation was two doses of Tropicamide on arrival at hospital. As the topical anaesthesia was applied I was hoping that would be enough - which it was. I observed two strong sources from the microscope surrounded by a creamy white speckled background, with a fenestrated 'screen' moving in front of the background, and partly obscuring it. Sadly I did not see the legendary bright monochromatic phosphenes that most of my patients reported. Time seemed to pass very quickly, and although I tried, I was unable to discern which part of the procedure was occurring at any instant. The only

clues I had were the background sounds from the phaco machine and comments made by the surgeon. The experience was novel, but non threatening, and I was relaxed and comfortable throughout, thanks to the skill of my surgeon and some I.V. Midazolam.

After the procedure I visited the surgeon's rooms for a pressure check before going home. I estimated the acuity in the operated left eye was around 6/60 at far while the pupil fully dilated, and there were haloes around LED lights on equipment and a 'fog' of unfocused light in the peripheral field. Around 9:30 p.m. I looked in the mirror while preparing for bed and noticed the pupil size was beginning to recover, so I set about testing my vision. Sitting in bed with the room lights on I compared monocular with binocular vision. I noticed better near acuity in the left eye than preoperatively, but extreme optical blur at mid and far range. My binocular perception was blurred at all distances, which I interpreted as signal averaging, since the unaided right vision intruded into consciousness at near and the myopic blur of the left eye intruded into my binocular consciousness at distance - creating more blur in both cases.

There was a large white ceiling fan directly overhead. The chromaticity, saturation, and brightness of the blades were all different between the eyes, but when I compared the binocular perception to each monocular perception the chromaticity from the left image was contributing more to the binocular perception than the brightness or contrast, so I realised I was wrong in assuming I was seeing simple signal averaging. The difference in chromaticity was analogous to the difference between a modern LED illuminant and an incandescent globe. The observation that different aspects of visual sensation contribute unequally to binocular object consciousness is interesting since it fits with the modern view of visual consciousness as a top down construct.

### Day 1.

Both pupils are now equal and I estimate the left acuity at near is N5 unaided. My mobile phone screen is in sharp focus through the left eye alone, but when I open the right eye the binocular perception is blurred. Theoretically this should change over the next few days. The enhanced chromaticity and contrast from the the left eye contribute to binocular perception even at mid and long

range, where there is very significant left defocus. From the near point I estimate the left refraction is at least minus 2.0 dioptres, so at present the anisometropia is over 2.5 dioptres. Despite that I can walk up and down stairs with confidence but when replacing the lid on the eye drop bottles I realise stereopsis is poor. The mid range blur is relieved by wearing my old multifocal glasses with the left lens removed.

### Day 2.

The operated eye remains comfortable and its focal length has hardly altered. The disturbing sense of optical blur I experience binocularly has decreased since yesterday, which I interpret as a sign of adaptation. I assume that persisting with binocular viewing will encourage that process. I can read text on my mobile phone equally well binocularly as with the left eye alone, but the screen has lower contrast binocularly. My wife had bilateral cataract surgery a few years ago since when she has been better than me at selecting colour coded coffee pods from our pantry. The difficult choices for me were between a pastel pink and an orange. When I now attempt that task using either monocular left viewing or binocular viewing those colours are easily distinguished in dim artificial light. That suggests to me that central processing is incorporating the most coherent and useful sensory input from either eye and generating an imaginary representation which is all that I have access to in consciousness. That process aligns with my understanding of recent cognitive science, but is of course the exact opposite to the naive realism implicit in the traditional ophthalmic literature I once took to be true. I visited the badly named 'Colorblindtest' website <sup>1</sup> to perform an online 100 hue test which revealed no errors in the left eye and 8 errors in the right.

### Day 3.

The near point in the left eye has receded slightly and now corresponds to a myopic refraction of around minus 1.75 dioptres so I no longer need to lean towards my laptop computer screen. The mid range view is less blurred binocularly than at first, but I suspect that is due more to central adaptation than the slight reduction in left myopia. The binocular view is slowly becoming more comfortable when not wearing glasses, but I still find it more comfortable to wear my old multifocal lens over the right eye. At long and mid range the

binocular perception hardly changes when I close the left eye, which being hyperopic, remains extremely defocused at both distances. This is different to the experience on day 1 when it seemed that the blur from the left eye was intruding into long range perception. Whereas chromaticity and contrast seemed to adapt quickly, it is taking longer for my brain to adapt to optical blur. Perhaps that is because chromaticity and contrast are secondary properties. I am perfectly comfortable playing music or shopping when wearing my spectacles, and only slightly uncomfortable at some distances without them. Stereopsis as judged by aligning eye drop bottles and lids is better with glasses on than off, but still not perfect. By alternately closing one eye it is obvious that my perception of chromaticity is now dominated by the left eye at all distances, even though optical resolution of the distant object is completely dominated by input from the right eye at far.

#### Day 4.

Near our farmhouse is a sign about the size of a car registration plate that says 'Parking.' I was previously familiar with the distance from which it was just legible since I have walked towards it dozens of times. At about the same distance there are parked vehicles with unfamiliar registration plates. I observed the 'Parking' sign through the left eye from around 6 metres, standing where I recall reading it easily in the past. I closed the left eye and without glasses was just able to distinguish the letters with the unaided right eye alone. When I then swapped eyes, to my surprise, the sign was not only legible through the myopic left eye but was perceived with far higher contrast than through the right eye. Since the right eye had only 0.5 dioptres of hyperopic defocus and the left 1.75 dioptres of myopic defocus at that distance it seemed impossible that my perception through the left eye could be entirely from left signal processing. I repeated the experiment while looking at unfamiliar number plates, starting with left monocular viewing. I was unable to read any of them but with right eye fixation I could read most letters. When I switched back to left fixation after deciphering the letters it seemed as if I could form an image of at least some of the letters, suggesting that memory was contributing to visual perception.

#### Day 5.

The myopia in the left eye now has stabilised at around minus 1.75 dioptres. Unaided near vision is startlingly clear at near, with high contrast and image saturation. I am very happy with the performance of my left lens implant. The disturbing sense of mid range blur that intruded at first is no longer present at any time with glasses on, but when moving about in a shopping mall or outdoors I occasionally experience a sensation like the peripheral field is closing in from the non fixing side. It is difficult to describe. I am now fully left eye dominant for all distances inside arms length, but fixation switches to right eye dominance at far. The distance at which fixation switches corresponds to the depth of focus of the left eye. I first detected this change in fixation yesterday afternoon, but am not certain when it began.

One could be forgiven for expecting a sense of 'unreality' at times during the adapting process, but I have not experienced it. That could be because at every point what I actually perceive in visual consciousness is an internal construct and the adaptation process is taking place prior to the generation of that construct. I have no conscious access to signal processing that breaks the afferent visual signal apart into different processing streams for position, shape, movement, colour, and so on, that generates 'pre-categorical icons'. Nor am I aware of the algorithmic processing that attach values like familiarity, syntactical meaning, category, or disposition to generate meaningful symbols. At some stage the top down work of imagining the world begins, using as input both the meaningful symbols made from the bottom up signal, memory, and attention. Reading the ancient philosophers for my philosophy degree I was amazed at the prescience of some of their intuitions, but it was not until I studied cognitive science that I fully realised that consciousness is not really about knowing the world, it is more about understanding it as a landscape of 'affordances.'

I know that surface colours I perceive in my conscious are actually symbolisations since what exists outside my head are mixtures of spectrophotometric energy distributed through object space. There are no colours outside my head, but since the logic of language was developed to map the naive realism of our pre-scientific forebears we are shackled by constant reference to object colour as if it does exist outside our heads. When I look at a visual illusion, like the duck-rabbit illusion, the physical artefact remains equally

ambiguous throughout, but my perception switches from a duck to a rabbit as I try to understand the ambiguity in it. Perhaps adapting to monovision involves learning to blend the various visual processing streams differently, and in addition learning to present pre-categorical icons differently at the stage of symbolic representation. I do not think it involves any change in how those meaningful symbols are 'imagined' into visual consciousness.

Monovision is poorly theorised by ophthalmologist, and as a result some are deceived into preferring less sensible options for optical correction even in subjects who have excellent motor and sensory fusion. One reason for that is much of the literature on anisometropia is derived from short term experiments on phacic subjects, which are not analogous to my view 'from the inside.' Theorising about sensory fusion is normally explained conceptually as blending of geometrical optics, and includes terms of craft like Bjerrum's area. Whilst that is of some use, such explanations are conspicuously silent about actual neurophysiology - because it is no better understood than consciousness. When faced with such an overwhelming lack of theoretical understanding it is sensible to rely instead on empirical observations in real people. There is a growing evidence for the plasticity of visual processing in adults, and even subjects wearing inverting prisms for extended periods mostly adapt to inversion within 3 days <sup>2</sup>.

#### Day 6.

The optical situation and binocular representation have stabilised. It is obvious my visual experience is much clearer as a result of the left surgery, and when I am not in the mode of self analysis the lived experience feels as if it has always been this way, rather than feeling novel or unfamiliar. How odd.

#### Day 7. Post operative review of left eye.

The results of my review appointment were that the left eye refraction is minus 1.75 sphere with plus 0.5 dioptres of astigmatism - a spherical equivalent of minus 1.5 dioptres. The left eye reads N4 unaided in good light at 40 cm, with 6/36 unaided at far, and corrects to 6/4. I was advised there is still a slight lens wobble with eye movement but I am not aware of it, and I have no

dysphotopsia. There were no problems detected so the surgical booking and lens selection for the right eye were confirmed. Although I look forward to reduced anisometropia next week I have adapted to the present arrangement surprisingly well in less than a week.

I had an ethical concern about my post operative care, since I felt obliged to follow the advice I gave my patients in the past, which differed from what my surgeon routinely recommends. He prescribes Chloramphenicol drops post operatively and recommends sleeping with a shield. I stopped using topical antibiotics post operatively after intra-cameral antibiotics became routine, because there is a small probability of undesirable side effects on the ocular surface but no possibility of a benefit if the wound is properly sealed. I also recommended patients to never wear a shield at night because of complications I encountered from doing so in the past. I never encountered a complication from patients sleeping against a clean pillow case. When I informed my surgeon of this he had no objection to me following my own regime, which solved my ethical problem.

### Days 8 - 13

In the next six days I did not discover any significant changes in visual perception apart from a little less awareness of the mid range blur that is still present when I alternate between eyes. I am now more aware than previously of the lack of uncorrected acuity in the right eye.

### Day 14 - The Second Operation

This time the dilating regime consisted of two drops of Cyclopentolate before leaving home. Sitting in the hospital lobby the right vision is so blurred after dilation that I have trouble seeing a large flat screen TV only 3 metres away. With the severe blur in the right eye I note my binocular perception is now dominated by left eye input to a slightly longer distance than it was before dilation - around 1.5 metres.

The second surgical experience was almost the same as the first, and the visual perceptions were only slightly different. The most significant difference was awareness of a pink/purple crescent in the far temporal periphery of my right visual field. Once again the legendary coloured photopsia were absent. At my request the surgeon narrated each step of the procedure but despite those clues the only stage at which I could see corresponding evidence of what was described to me occurred during lens insertion and dialling. Objects inside the cornea are of course unable to generate the vergence required for a retinal focus, but I had expected to see moving silhouettes but that was not the case. This time the pupil took over 30 hours to return to normal and the unfocused light streaming into the eye around the outside of the lens optic created a disturbing 'fog' around objects and a circular halo around LED lights. Despite these aberrations I could see objects beyond 3 metres with a clarity similar to the unaided vision in that eye pre-operatively.

### Day 15

The right pupil remained dilated all day. Right monocular vision was best over a shallow range around 4 metres. Road signs appeared almost as legible as the unaided view had been pre-operatively, but mid range acuity was better. A pinhole improved the sharpness at far.

### Day 16

Finally the right pupil is back to normal this morning. I estimate right acuity is 6/6 minus at far and around N36 at near. The right tear film feels 'sticky,' which may be contributing to less than perfect acuity at far. The contrast at far not only improves with a pinhole, but also with sunglasses. I wonder if the extra trolands of retinal irradiance are producing some reflected scatter in the fundus, and perhaps I will need to adapt to higher illuminance as well as to everything else. Motor fixation now involves the left eye inside 1 metre and the right eye for longer range. Incidentally, to test fixation I stand a marker pen on its end near one end of a long counter and arrange objects beyond it at various distances, then adjust my posture so that the marker aligns with one target when viewed binocularly. To discover which eye is fixing I alternately close each eye. I am always careful to avoid handling the occluder, and prefer a marker

pen to a hole in a card as it is easier to manage by myself. Chromaticity and saturation are now symmetrical.

I am using my mobile phone, laptop and desktop computer without glasses for the first time in 20 years, but to explore my limitations at mid range I visited the supermarket. Labels on the same side of the aisle are perfectly clear but across a wide aisle the labels on the other side are blurred, although I could read the price signs on the shelves. Since perception is more often experienced as part of action than contemplation I am confident I will not need glasses for mid range activities.

### Day 17

It is now the third day since the second procedure. Outside my window the canopy of Plane trees are silhouetted against the sky at a distance of around 400 metres. The triangular lobes of the upper leaves are clearly visible where they form a horizon against the sky, so I assume binocular distance acuity would be about 6/5, and I have no awareness of the blur in the left eye at that range when viewing binocularly. Mid range clarity has improved a little but text at a distance of 1 to 1.2 metres is less distinct than it was in the past when I was wearing multifocal glasses, although better than it was without them. Near vision is clear and effortless, courtesy of the left eye, and binocular vision at near does not involve any awareness of the blur from the right eye even though that signal has a saturation and chromaticity that matches the left eye.

Moving around in a confined environment 'feels' different to previously. It is as if my body image maps differently onto my immediate environment, but it is a beneficial change since I have more confidence that I will not bump into close objects when moving in confined spaces. For example, at our farm I often need to climb in or out of a vehicle while holding a large bag or tool box with both hands, and I now feel it is less likely I will bump against the vehicle. I assume our optical perspective biases how we represent our own body within our egocentric map of the environment. A hyperopic spectacle correction might magnify the visual field, increase the rate of 'retinal slip' as objects move across the field, and distort the perceptual space we map as 'self.' All of that is important for action guiding.

### Day 18 - 20

The most significant adaptation in the last few days has been that when using mid range vision between 1.0 to 1.2 metres I no longer have a sensation like the field of vision is closing in on one side. Unfamiliar objects seem clearer at mid range than before. I tested myself with text and numbers and although mid range binocular acuity is not objectively perfect it is better than monocularly. While being driven I looked around at road signs, and could read a temporary speed restriction sign over 1 km ahead, and I have no trouble reading street names on side roads from the distance required to safely navigate. There are no haloes around LED lights or TV screens in the dark, and I am not aware of any aberrations.

### Day 21 - Post operative review of right eye

My surgeon reported no problems after examining both eyes, but the refractive result for the right eye was +0.25 whereas the pre operative target was -0.25. The 0.5 dioptre difference accounts for some of the difficulty I had with mid range over the last week. The refraction in the left eye is still minus 1.5 dioptres spherical equivalent. The unaided acuities are right 6/36, N4, left 6/5, N36. Reading N4 monocularly with the left eye was difficult but the moment I opened the right eye, despite its lack of near focus, reading N4 became easy at 40 cm. Also when the right eye was struggling to read the 6/5 line monocularly the binocular view noticeably improved, despite the left myopia. This means that fusion is occurring but stereopsis is another thing. A Titmus stereo test at 40 cm was negative unaided, but with a +1.5 sphere before the right eye I all three images were obvious. When I wear an old pair of bifocal sunglasses, which are plano at far with a +1.5 reading addition, the image of a near object is perceived through the top section with the left eye and the bottom section with the right eye. By moving them up and down while viewing a close target I force the brain to repeatedly switch between inputs, and that switching is instantaneous and subconscious. I have no subjective awareness of which eye is contributing the reading task as I move the spectacles up and down.

After I complete my post operative drops I will obtain a set of reading glasses for occasions when I might need stereopsis in the future, even though I have

not found a need for them in the last week. That decision is justified by the same logic as having a first aid kit on a bushwalk. Despite very serious introspection I have not detected aberrations or dysphotopsias, and visual consciousness 'feels' similar to what I recall from years ago. That is about as good an endorsement for monovision, in subjects with well developed sensory fusion, as anyone could expect.

## Comments

When choosing a lens implant design my preference was not to trade any amount of contrast for depth of focus, since high contrast is a far greater good than depth of focus for me. Greater depth of focus is readily available with part time glasses if I ever want it in the future. I rejected all the aberrating lens implant designs that trade under various misleading names like 'multifocal' and extended depth of focus because I trusted my brain to adapt to high contrast images.

Some people reading this may not be familiar with the understanding from cognitive science that visual consciousness is an 'imagined top down construct,' using symbols that represent the world as full of meaningful objects. This is radically different to the traditional view of visual consciousness as merely a window on the world through which raw data flows in a bottom up direction. The reflections in this diary make sense only from the cognitive science perspective, and I believe that is why monovision works as well as it does.

I suspect that 'composite multifocal implants' work as well as they do because of a different feature of visual processing, involving the lateral geniculate nucleus (LGN). According to the recent literature only 20% of the relay synapses in the LGN are retinal in origin, 50% are from layer VI of the cerebral cortex, and the remainder from brainstem<sup>3</sup>. A simplified description of the cortico-geniculate signal is that it consists of an 'averaged' representation of the signal that is presently in the cortex, and that signal is used to inhibit much of the bottom up signal (mainly parvocellular) that reaches the LGN. That evolved process is highly adaptive because it saves the brain an enormous amount of duplicated processing, and brains are metabolically expensive to

operate. I suspect the credit for any success from 'composite multifocal implants' is owed mainly to that process, but also to top down processes that generate abstract symbols and place them into consciousness. Of course there are times when the visual system simply passes on the bottom up signal without converting it into a meaningful symbol. This includes the dysphotopsias and haloes experienced by people with 'composite multifocal implants.' I am very grateful not to experience those aberrations.

I would like to thank my surgeon and his team for their skill and understanding, and the staff at the Perth Eye Hospital for their expert care.

#### References.

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